DESCRIPTION

CUK CONVERTER WITH INDUCTORS AND CAPACITORS ON BOTH POWER LINES

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a capacitor-coupled power supply apparatus.

Description of Related Art

10   To obtain a voltage having a desired value, there are instances where a transformer is used in a power supply apparatus. Such a transformer also serves as a member for insulating the primary side from the secondary side.

On the other hand, for miniaturization and weight saving, 15 there may be desired a power supply apparatus requiring no transformer.

Unlike in a power supply apparatus using a transformer, it is generally difficult in a power supply apparatus using no transformer to keep the insulation between the power supply side 20 and the load side.

To keep such insulation, there is conventionally proposed a power supply apparatus of the type in which a capacitor is connected in series between the power supply side and the load side (Japanese Patent Laid-Open Publication No. H9-74741).

25   As a matter of fact, the power supply apparatus of the

type above-mentioned can provide insulation for a direct current,
but cannot ensure a sufficient insulation for an alternating
current.

In view of the foregoing, it is an object of the present ·
5   invention to provide a power supply apparatus capable of assuring
a sufficient insulation not only for a direct current, but also
for an alternating current.

SUMMARY OF THE INVENTION

10   A power supply apparatus according to the present invention
is arranged such that inductors are respectively inserted in
series at the positive and negative sides of lines for guiding
a direct current supplied from an alternating current power
supply through a rectification circuit, or a direct current
15   supplied directly from a direct current power supply, that a
switching element is connected in parallel to the output ends
of the inductors, and that capacitors are respectively inserted
in series between the output end of the positive-side inductor
and a load, and between the output end of the negative-side
20   inductor and the load.

The arrangement above-mentioned is characterized in that
the inductors are respectively inserted in series at the positive
and negative sides of the lines for guiding a direct current.

By this characteristic, the insulation between the power
25   supply and the load is achieved not only for a direct current

but also for an alternating current.

Preferably, the ratio in capacitance of the positive-side inductor to the negative-side inductor is a reciprocal number of the ratio in capacitance of the capacitor connected in series to the positive-side inductor, to the capacitor connected in series to the negative-side inductor.

By satisfying the relationship above-mentioned, the insulation between the power supply and the load can perfectly be achieved. Even though this relationship is not satisfied, the insulation between the power supply and the load is achieved in a practical level.

The positive-side inductor and the negative-side inductor may be the same in capacitance as each other, and the capacitor connected in series to the positive-side inductor and the capacitor connected in series to the negative-side inductor may be the same in capacitance as each other. This is the case where the ratio in capacitance above-mentioned is equal to 1.

A rectification circuit and a smoothing circuit may be connected to the output ends of the capacitors. According to the arrangement above-mentioned, there can be formed a direct-current power supply apparatus for supplying a direct-current voltage, thus further improving the insulation level.

Smoothing inductors may respectively be inserted in the positive-side and negative-side lines of the rectification

circuit. The combination of these smoothing inductors with the input-end inductors provides a smooth direct current less in pulsation.

According to the capacitor-coupled power supply apparatus
5   of the present invention, even though a resistance is connected between the power supply side and the load side, neither a direct current nor an alternating current flows in this resistance. Accordingly, the insulation between the input side and the output side can be ensured without the use of a transformer. Thus,
10 there can be provided a power supply apparatus suitable for a computer, a variety of communication devices and the like.

Further, according to the capacitor-coupled power supply apparatus of the present invention, the harmonic distortion given to the power transmission or distribution side is small. The
15 resonance conditions can readily be satisfied by the inductors and capacitors, enabling noise to be absorbed. Thus, a power supply apparatus generating no noise can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS
20   Fig. 1 is a schematic circuit diagram of a capacitor-coupled direct-current power supply apparatus according to the present invention;

Fig. 2 is a circuit diagram of a conventional capacitor-coupled power supply apparatus in which an inductor
25 is inserted only at the positive side of a direct current after

converted;

Fig. 3 is a circuit diagram used for verifying the effect of the present invention;

Fig. 4 is a graph illustrating the voltage waveforms, with the passage of time, of the both-end voltage Vi of a resistance Ri and the load voltage VL across the both ends of a load resistance RL after a direct-current electricity has been turned ON in the circuit in Fig. 3;

Fig. 5 is another circuit diagram used for verifying the effect of the present invention;

Fig. 6 is a graph illustrating the voltage waveforms, with the passage of time, of the both-end voltage Vi of a resistance Ri and the load voltage VL across the both ends of a load resistance RL after a direct-current electricity has been turned ON in the circuit in Fig. 5;

Fig. 7 is a circuit diagram of a direct current power supply apparatus of prior art; and

Fig. 8 is a graph illustrating the voltage waveforms, with the passage of time, of the both-end voltage Vi of a resistance Ri and the load voltage VL across the both ends of a load resistance RL after a direct-current electricity has been turned ON in the circuit in Fig. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following will discuss in detail an embodiment of the

present invention with reference to attached drawings.

Fig. 1 is a schematic circuit diagram of a capacitor-coupled direct-current power supply apparatus according to the present invention.

5   An alternating current voltage of a commercial alternating current power supply 1 is converted into a direct (pulsating) current by a first rectification circuit 2. Inductors L1, L2 are respectively inserted at the positive and negative sides of the converted direct current, and a high frequency switch

10   S is connected in parallel to the output sides of the inductors L1, L2.

Further, capacitors C1, C2 are respectively connected to the inductors L1, L2, and a diode D forming a second rectification circuit is connected to the output sides of the capacitors C1,

15   C2. Connected to the output side of the diode D are an inductor L3 and a capacitor C3 which form a smoothing circuit 3.

The capacitances of the inductors L1, L2 and the capacitances of the capacitors C1, C2 have a relationship according to the following equation (1):

20       $L1/L2 = C2/C1$ .... (1)

As a special case, this relationship includes a relation of L1=L2 and C1=C2.

Fig. 2 is a circuit diagram of prior art in which an inductor L1 is inserted only at the positive side of a direct current

25   after converted, and in which no inductor is inserted at the

negative side.   The arrangement of other circuit elements is the same as that of Fig. 1.

As shown in Fig. 1, the present invention is arranged such that the inductor L1 is disposed at the positive side of a direct

5   current, that the inductor L2 is disposed at the negative side of the direct current, and that the capacitances of the inductors L1, L2 and the capacitances of the capacitors C1, C2 satisfy the equation (1) above-mentioned, thus achieving both a direct-current   insulation   and   an   alternating-current

10 insulation between the power supply and the output of the smoothing circuit 3.

This can be proven, as will be later discussed in Examples, by making sure that neither a direct-current electricity nor an alternating-current electricity flows in a resistance

15 connected between the power supply and the output side of the smoothing circuit 3.

In the foregoing, an embodiment of the present invention has been discussed, but the present invention should not be limited to this embodiment. For example, the present invention

20 can also be applied to a direct-current input type power supply apparatus having neither the alternating current power supply 1 nor the first rectification circuit 2. Further, the present invention can also be applied to an alternating-current input type power supply apparatus which is not provided with the first

25 rectification circuit 2 and which is connected directly to the

8

alternating current power supply 1. Further, the present

invention can also be applied to an alternating-current output

type power supply apparatus with both the diode D and the smoothing

circuit 3 omitted. Besides, various modifications may also be

5   made within the scope of the present invention.

        <Example 1>

        Fig. 3 is a circuit diagram used for verifying the effect

of the present invention. The circuit arrangement and the

circuit constants were entered into a computer and the voltages

10   and current waveforms of respective parts were estimated with

the use of a circuit analyzing software.

        The circuit in Fig. 3 is of the direct-current-input and

direct-current-output type, and the alternating current power

supply 1 and the first rectification circuit 2 in Fig. 1 are

15   omitted. There are used coils of $15 \mu H$ as members corresponding

to the inductors L1, L2, and capacitors of $0.01 \mu F$ as members

corresponding to the capacitors C1, C2. Accordingly, this

circuit satisfies the relationship of L1=L2 and C1=C2. The

chopping frequency is 200 kHz.

20   A resistance of 20Ω is connected as a load RL. Connected

to one end of the load RL is a resistance Ri to be used for

investigating the insulation.

        Fig. 4 is a graph illustrating the voltage waveforms, with

the passage of time, of the both-end voltage Vi of the resistance

25   Ri and the load voltage VL across the both ends of the load

resistance RL after a direct-current electricity has been turned
ON.

In Fig. 4, the voltages VL, Vi on the axis of ordinate
are shown in volt, while the time on the axis of abscissas is
5   shown in μ sec.

As shown in the graph in Fig. 4, the load voltage VL quickly
rises up after the power has been turned ON, but the voltage
Vi remains substantially zero. Accordingly, the insulation
between the input and output sides is ensured.

10   <Example 2>

Fig. 5 is another circuit diagram used for verifying the
effect of the present invention. There are used coils of 10
μ H and 20 μ H as members respectively corresponding to the
inductors L1 and L2, and capacitors of 0.014 μ F and 0.007 μ F
15   as members respectively corresponding to the capacitors C1 and
C2. Accordingly, this circuit satisfies the relationship of
L1/L2 = C2/C1 = 0.5.

Fig. 6 is a graph illustrating the voltage waveforms, with
the passage of time, of the both-end voltage Vi of a resistance
20   Ri and a load voltage VL after a direct-current electricity has
been turned ON.

As shown in the graph in Fig. 6, likewise in Fig. 4, the
load voltage VL quickly rises up after the power has been turned
ON, but the voltage Vi remains substantially zero.

25   <Comparative Example>

Fig. 7 is a circuit of prior art. In this circuit, a coil

of 30μH is inserted only at the positive side of the direct

current power supply. Capacitors of 0.01μF are used as done

in Example 1.

5   Fig. 8 shows the voltage waveforms, with the passage of

time, of the both-end voltage Vi of a resistance Ri and a load

voltage VL after a direct-current electricity has been turned

ON in the circuit in Fig. 7. It is understood from the graph

in Fig. 8 that a large high frequency voltage of frequency 200kHz

10   is being superposed on the both-end voltage Vi of the resistance

Ri.

Accordingly, the insulation for an alternating current

is not sufficient. If the resistance Ri is a human body, a high

frequency electric current flows in the human body, causing the

15   same to receive an electric shock.